101 - $790.00
104 - $270.00
105 - $130.00

A

PATENT

Attorney's Docket No. 4030B

Box Patent Application
Commissioner of Patents and Trademarks
Washington, D. C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of Inventor(s):

DAVID MICHAEL GLENN, SHEPHERDSTOWN, WV;
DENNIS G. SEKUTOWSKI, STOCKTON, NJ; GARY J. PUTERKA,
SHEPHERDSTOWN, WV.

For (Title): **METHOD FOR PROVIDING ENHANCED PHOTOSYNTHESIS**

1. Type of Application

This new application is for an

- ☐ Original
- ☐ Design
- ☐ Divisional
- ☐ Continuation
- ■ Continuation-in-part (CIP)

2. Benefit of Prior U.S. Application(s) (35 U.S.C. 120)

■ The new application being transmitted claims the benefit of prior U.S. application(s) and enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

Certification under 37 CFR 1.10

I hereby certify that this New Application Transmittal request and the documents referred to as attached therein are being deposited with the United States Postal Service on November 18 , 1997 in an envelope as "Express Mail Post Office to Addressee" service under 37 CFR 1.10, Mailing Label Number EM361217463 Label Number addressed to the Assistant Commissioner of Patents and Trademarks, Washington, D.C. 20231-0001.

Janet Szot

3. Papers Enclosed which are required for filing date under 37 CFR 1.53(b) Regular) or 37 CFR 1.153 (Design) Application.

21 Pages of specification

4 Pages of claims

1 Pages of Abstract

_____ Sheets of Drawing

☐ Formal
☐ Informal
☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)". 37 CFR 1.84(b)

4. Additional papers enclosed:

☐ Preliminary Amendment
☐ Information Disclosure Statement (37 CFR 1.98)
☐ Form PTO-1449
☐ Citations
☐ Other

5. Declaration or oath

☐ Enclosed - signed by inventors

■ Not enclosed.

6. Inventorship Statement

The inventorship for all the claims in this application are:

■ The same
or
☐ Not the Same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
☐ is submitted
■ will be submitted later.

7. Language -

X English

8. Assignment

☐ an assignment of the invention

☐ is attached. a Separate "cover sheet for assignment document accompanying new patent application, or form PTO 1595 is also attached

■ will follow

9. Certified Copy of Application(s) from which priority is claimed:

_____

_____

☐ **is attached**

☐ **will follow**

10. Fee Calculation (37 CFR 1.16)

A. X Regular application

CLAIMS AS FILED

Number filed		Number Extra		Rate	Basic Fee 37 CFR 1.16(a) **$ 790.00**
Total Claims	17	-20 =	X	22.00	$ -0-
Independent Claims	2	- 3 =	X	82.00	-0-
Multiple dependent claims (if any) 1				270.00	$ 270.00
Total Basic Filing Fee					$1,060.00

11. Fee payment being made at this time

X	Basic Filing Fee	$1,060.00
☐	Recording Assignment	$

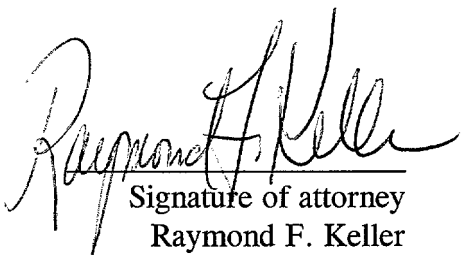
12. Charge Account No. 05-1070 in the amount of $1,060.00

13. Commissioner is hereby authorized to charge any additional fees required by this paper and during the entire pendency of this application to Account No. 05-1070.

14. Credit any overpayment to Account No. 05-1070.

Reg.No. 28,960

Tel. No. (732) 205-5937



Signature of attorney
Raymond F. Keller
Engelhard Corporation
101 Wood Avenue
P.O. Box 770
Iselin, New Jersey 08830

Attorney's Docket No. 4030B **PATENT**

ADDED PAGES FOR APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED

NOTE: "In order for an application to claim the benefit of a prior filed copending national application, the prior application must name as an inventor at least one inventor named in the later filed application and disclose the named inventor's invention claimed in at least one claim of the later filed application in the manner provided by the first paragraph of 35 U.S.C. 112." 37 CFR 1.78(a).

NOTE: "In addition the prior application must be (1) complete as set forth in § 1.51, or (2) entitled to a filing date as set forth in § 1.53(b) and include the basic filing fee set forth in § 1.16; or (3) entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(l) within the time period set forth in § 1.53(d)." 37 CFR 1.78(a).

17. Relate Back

WARNING: *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

(complete the following, if applicable)

☐ Amend the specification by inserting, before the first line, the following sentence:

A. 35 U.S.C. 119(e)

NOTE: "Any nonprovisional application claiming the benefit of one or more prior filed copending provisional applications must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior provisional application, identifying it as a provisional application, and including the provisional application number (consisting of series code and serial number)." 37 C.F.R. § 1.78(a)(4).

☐ "This application claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	FILING DATE
_____ /_____	_____ "
_____ /_____	_____ "
_____ /_____	_____ "

B. 35 U.S.C. 120, 121 and 365(c)

NOTE: "Any nonprovisional application claiming the benefit of one or more prior filed copending nonprovisional applications or international applications designating the United States of America must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior application, identifying it by application number (consisting of the series code and serial number) or international application number and international filing date and indicating the relationship of the applications. Cross-references to other related applications may be made when appropriate. (See § 1.14(b))." 37 C.F.R. § 1.78(2).

☒ "This application is a

- ☐ continuation
- ☒ continuation-in-part
- ☐ divisional

of copending application(s)

☒ application number 08 /812,301 filed on March 5, 1997 "

☐ International Application _____ filed on

_____ and which designated the U.S."

NOTE: The proper reference to a prior filed PCT application that entered the U.S. national phase is the U.S. serial number and the filing date of the PCT application that designated the U.S.

NOTE: (1) Where the application being transmitted adds subject matter to the International Application, then the filing can be as a continuation-in-part or (2) if it is desired to do so for other reasons then the filing can be as a continuation.

☐ "The nonprovisional application designated above, namely application _____ / _____, filed _____, claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	FILING DATE
_____ /_____	_____ "
_____ /_____	_____ "
_____ /_____	_____ "

NOTE: The deadline for entering the national phase in the U.S. for an international application was clarified in the Notice of April 28, 1987 (1079 O.G. 32 to 46) as follows:

"The Patent and Trademark Office considers the International application to be pending until the 22nd month from the priority date if the United States has been designated and no Demand for International Preliminary Examination has been filed prior to the expiration of the 19th month from the priority date and until the 32nd month from the priority date if a Demand for International Preliminary Examination which elected the United States of America has been filed prior to the expiration of the 19th month from the priority date, provided that a copy of the international application has been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively. If a copy of the international application has not been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively, the international application becomes abandoned as to the United States 20 or 30 months from the priority date respectivley. These periods have been placed in the rules as paragraph (h) of § 1.494 and paragraph (i) of § 1.495. A continuing application under 35 U.S.C. 365(c) and 120 may be filed anytime during the pendency of the international application."

18. Relate Back—35 U.S.C. 119 Priority Claim for Prior Application

The prior U.S. application(s), including any prior International Application designating the U.S., identified above in item 17B, in turn itself claim(s) foreign priority(ies) as follows:

country	appln. no.	filed on

The certified copy(ies) has (have)

☐ been filed on _____, in prior application 0 /_____, which was filed on _____.

☐ is (are) attached.

WARNING: *The certified copy of the priority application that may have been communicated to the PTO by the International Bureau may **not** be relied on without any need to file a certified copy of the priority application **in the continuing application.** This is so because the certified copy of the priority application communicated by the International Bureau is placed in a folder and is not assigned a U.S. serial number unless the national stage is entered. Such folders are disposed of if the national stage is not entered. Therefore, such certified copies may not be available if needed later in the prosecution of a continuing application. An alternative would be to physically remove the priority documents from the folders and transfer them to the continuing application. The resources required to request transfer, retrieve the folders, make suitable record notations, transfer the certified copies, enter and make a record of such copies in the Continuing Application are substantial. Accordingly, the priority documents in folders of international applications that have not entered the national stage may not be relied on. Notice of April 28, 1987 (1079 O.G. 32 to 46).*

19. Maintenance of Copendency of Prior Application

NOTE: The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the papers constituting the filing of the continuation application. Notice of November 5, 1985 (1060 0.G. 27).

A. ☐ Extension of time in prior application

*(This item **must** be completed and the papers filed **in the prior application,** if the period set in the prior application has run.)*

☐ A petition, fee and response extends the term in the pending **prior** application until _____.

☐ A **copy** of the petition filed in prior application is attached.

B. ☐ Conditional Petition for Extension of Time in Prior Application

(complete this item, if previous item not applicable)

☐ A conditional petition for extension of time is being filed in the pending **prior** application.

☐ A **copy** of the conditional petition filed in the prior application is attached.

20. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed

*NOTE: "If the continuation, continuation-in-part, or divisional application is filed by less than all the inventors named in the prior application a statement **must** accompany the application when filed requesting deletion of the names of the person or persons who are not inventors of the invention being claimed in the continuation, continuation-in-part, or divisional application." 37 CFR 1.62(a) [emphasis added]. (dealing with the file wrapper continuation situation).*

NOTE: "In the case of a continuation-in-part application which adds and claims additional disclosure by amendment, an oath or declaration as required by § 1.63 must be filed. In those situations where a new oath or declaration is required due to additional subject matter being claimed, additional inventors may be named in the continuing application. In a continuation or divisional application which discloses and claims only subject matter disclosed in a prior application, no additional oath or declaration is required and the application must name as inventors the same or less than all the inventors in the prior application." 37 CFR 1.60(c) (dealing with the continuation situation).

(complete applicable item (a), (b) and/or (c) below)

(a) ☐ This application discloses and claims only subject matter disclosed in the prior application whose particulars are set out above and the inventor(s) in this application are

- ☐ the same.
- ☐ less than those named in the prior application. It is requested that the following inventor(s) identified for the prior application be deleted:

_____

(type name(s) of inventor(s) to be deleted)

(b) ☒ This application discloses and claims additional disclosure by amendment and a new declaration or oath is being filed. With respect to the prior application, the inventor(s) in this application are

- ☒ the same.
- ☐ the following additional inventor(s) have been added:

_____

(type name(s) of inventor(s) to be added)

(c) The inventorship for all the claims in this application are

- ☐ the same.
- ☐ not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made
  - ☐ is submitted.
  - ☐ will be submitted.

21. Abandonment of Prior Application *(if applicable)*

☐ Please abandon the prior application at a time while the prior application is pending, or when the petition for extension of time or to revive in that application is granted, and when this application is granted a filing date, so as to make this application copending with said prior application.

NOTE: According to the Notice of May 13, 1983 (103, TMOG 6-7), the filing of a continuation or continuation-in-part application is a proper response with respect to a petition for extension of time or a petition to revive and should include the express abandonment of the prior application conditioned upon the granting of the petition and the granting of a filing date to the continuing application.

22. Petition for Suspension of Prosecution for the Time Necessary to File an Amendment

WARNING: *"The claims of a new application may be finally rejected in the first Office action in those situations where (1) the new application is a continuing application of, or a substitute for, an earlier application, and (2) all the claims of the new application (a) are drawn to the same invention claimed in the earlier application, and (b) would have been properly finally rejected on the grounds of art of record in the next Office action if they had been entered in the earlier application." MPEP, § 706.07(b).*

NOTE: Where it is possible that the claims on file will give rise to a first action final for this continuation application and for some reason an amendment cannot be filed promptly (e.g., experimental data is being gathered) it may be desirable to file a petition for suspension of prosecution for the time necessary.

(check the next item, if applicable)

☐ There is provided herewith a Petition To Suspend Prosecution for the Time Necessary to File An Amendment (New Application Filed Concurrently)

23. Small Entity (37 CFR § 1.28(a))

☐ Applicant has established small entity status by the filing of a verified statement in parent application /________ on ________ .

☐ A copy of the verified statement previously filed is included.

WARNING: *"Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. Applications filed as continuations, divisions or continuations-in-part of a parent application must include a reference to a verified statement filed in the parent application if status as a samll entity is still proper and desired." 37 CFR § 1.28(a).*

24. NOTIFICATION IN PARENT APPLICATION OF THIS FILING

☒ A notification of the filing of this *(check one of the following)*

☐ continuation

☒ continuation-in-part

☐ divisional

is being filed in the parent application, from which this application claims priority under 35 U.S.C. § 120.

Title: METHOD FOR PROVIDING ENHANCED PHOTOSYNTHESIS

Cross-reference to Related Applications

This application is a continuation-in-part of U.S. Patent Application No. 08/812301, filed March 5, 1997, which is incorporated herein by reference for its teachings related to the invention disclosed herein.

Field of the Invention

The present invention is directed to a method for enhancing the photosynthesis of horticultural crops.

Background of the Invention

Improved yield or plant productivity is a desired horticultural effect on horticultural crops that is generally limited by the amount of light, temperature, relative humidity and other uncontrollable environmental factors when pests, water and nutrients are adequately controlled. Particulate matter from a wide range of sources is generally regarded as limiting plant productivity. See for example, Farmer, "The Effects of Dust on Vegetation--A Review," *Environmental Pollution* 79:63-75 (1993).

The prior art has discussed photosynthesis and the effects of environmental stresses on plants. See, for example; Nonomora and Benson, "Methods and compositions for enhancing carbon fixation in plants," U.S. 5,597,400, Stanhill, G., S. Moreshet, and M. Fuchs. "Effect of Increasing Foliage and Soil Reflectivity on the Yield and Water Use Efficiency of Grain Sorghum,"

Agronomy Journal 68:329-332 (1976); Moreshet, S., Y. Cohen, and M. Fuchs. "Effect of Increasing Foliage Reflectance on Yield, Growth, and Physiological Behavior of a Dryland Cotton Crop," *Crop Science* 19:863-868 (1979), which states that "within 2 days after spraying the kaolin reduced $^{14}CO_2$ uptake (photosynthesis) by more than 20%" and "the kaolin sprays would appear to reduce transpiration more than photosynthesis"; Bar-Joseph, M. and J. Frenkel, "Spraying citrus plants with kaolin suspensions reduces colonization by the spiraea aphid (Aphis citricola van der Goot)" *Crop Protection* 2(3):371-374 (1983), which states that "The reasons for this [yield increase of Stanhill, Ibid. and Moeshet, Ibid.] are uncertain [because photosynthesis is reduced] but aphid and virus control may have contributed to this yield increase"; Rao, N.K. S., "The Effects of Antitranspirants on Leaf Water Status, Stomatal Resistance and Yield in Tomato," *J. of Horticultural Science* 60:89-92 (1985); Lipton, W.J., and F. Matoba, "Whitewashing to Prevent Sunburn of 'Crenshaw' Melons," *HortScience* 6:434-345 (1971); Proctor, J. T. A. And L.L. Creasy "Effect of Supplementary Light on Anthocyanin Synthesis in 'McIntosh' Apples," *J. Amer. Soc. Hort. Sci* 96:523-526 (1971); Lord, W.J, and D. W. Greene, "Effects of Summer Pruning on the Quality of 'McIntosh' Apples," *HortScience* 17:372-373.

Therefore, there is still a need for cost effective inert, nontoxic methods for enhancing photosynthesis of horticultural crops. The prior art teaches away from the use of highly reflective inert particles of the

instant invention in that increasing reflectivity reflects photosynthetically active light, thus, reducing photosynthesis. Unexpectedly, the instant invention results in an opposite effect - enhanced photosynthesis.

Summary of the Invention

This invention relates to a method for enhancing the photosynthesis of horticultural crops which comprises applying to the surface of said horticultural crop an effective amount of one or more highly reflective particulate materials, said particulate materials being finely divided, and wherein the particles as applied allow for the exchange of gases on the surface of said crop.

Detailed Description of the Invention

This invention relates to a method for enhancing the photosynthesis of horticultural crops. Photosynthesis is the process by which photosynthetic plants utilize solar energy to build carbohydrates and other organic molecules from carbon dioxide and water. The conversion of carbon dioxide to such organic molecules is generally referred to as carbon fixation or photosynthesis and, in most plants, occurs by the reductive pentose phosphate cycle, generally referred to as the C-3 cycle. The study of the path of carbon in photosynthesis four decades ago (A.A. Benson (1951), "Identification of ribulose in $^{14}CO_2$ photosynthesis products" *J. Am.Chem. Soc.* 73:2971; J.R. Quayle et al. (1954), "Enzymatic carboxylationof ribulose diphosphate"

J. Am. Chem. Soc. 76:3610) revealed the nature of the carbon dioxide fixation process in plants. The effects of enhanced photosynthesis are typically observed by increased yields/productivity, e.g., increased fruit size or production (usually measured in weight/acre), improved color, increased soluble solids, e.g. sugar, acidity, etc., and reduced plant temperature.

The horticultural crops to which this invention relate are actively growing and/or fruiting agricultural and ornamental crops and the products thereof, including those selected from the group consisting of fruits, vegetables, trees, flowers, grasses, roots, seeds and landscape and ornamental plants.

The particulate materials useful for the purposes of this invention are highly reflective. As used herein, "highly reflective" means a material having a "Block Brightness" of at least about 80 and preferably at least about 90 and more preferably at least about 95 as measured by TAPPI standard T 646. Measurements can be made on a Reflectance Meter Technidyne S-4 Brightness Tester manufactured by Technidyne Corporation which is calibrated at intervals not greater than 60 days using brightness standards (paper tabs and opal glass standards) supplied by the Institute of Paper Science, or Technidyne Corporation. Typically a particle block or plaque is prepared from 12 grams of a dry (<1% free moisture) power. The sample is loosely placed in a cylinder holder and a plunger is slowly lowered over the sample to a pressure of 29.5 - 30.5 psi and held for about 5 seconds. The pressure is released and the plaque

is examined for defects. A total of three plaques are prepared and three brightness values are recorded on each plaque by rotating the plaque about 120 degrees between readings. The nine values are than averaged and reported.

The finely divided particulate materials useful for the purposes of this invention may be hydrophilic or hydrophobic materials and the hydrophobic materials may be hydrophobic in and of themselves, e.g., mineral talc, or may be hydrophilic materials that are rendered hydrophobic by application of an outer coating of a suitable hydrophobic wetting agent (e.g., the particulate material has a hydrophilic core and a hydrophobic outer surface).

Typical particulate hydrophilic materials useful for the purposes of this invention include: minerals, such as calcium carbonate, talc, kaolin (both hydrous and calcined kaolins, with calcined kaolins being preferred), bentonites, clays, pyrophyllite, silica, feldspar, sand, quartz, chalk, limestone, precipitated calcium carbonate, diatomaceous earth and barytes; functional fillers such as aluminum trihydrate, pyrogenic silica, and titanium dioxide.

The surfaces of such materials can be made hydrophobic by addition of hydrophobic wetting agents. Many industrial mineral applications, especially in organic systems such as plastic composites, films, organic coatings or rubbers, are dependent upon just such surface treatments to render the mineral surface hydrophobic; see, for example, Jesse Edenbaum, Plastics

Additives and Modifiers Handbook, Van Nostrand Reinhold, New York, 1992, pages 497-500 which is incorporated herein by reference for teachings of such surface treatment materials and their application. So-called coupling agents such as fatty acids and silanes are commonly used to surface treat solid particles as fillers or additives targeted to these industries. Such hydrophobic agents are well known in the art and common examples include: organic titanates such as Tilcom® obtained from Tioxide Chemicals; organic zirconate or aluminate coupling agents obtained from Kenrich Petrochemical, Inc.; organofunctional silanes such as Silquest® products obtained from Witco or Prosil® products obtained from PCR; modified silicone fluids such as the DM-Fluids obtained from Shin Etsu; and fatty acids such as Hystrene® or Industrene® products obtained from Witco Corporation or Emersol® products obtained from Henkel Corporation (stearic acid and stearate salts are particularly effective fatty acids and salts thereof for rendering a particle surface hydrophobic).

Examples of preferred particulate materials suitable for the purposes of this invention that are commercially available from Engelhard Corporation, Iselin, NJ are the calcined kaolins sold under the trademark Satintone® and the siloxane treated calcined kaolins sold under the trademark Translink®; and calcium carbonate commercially available from English China Clay under the trademarks Atomite® and Supermite® and stearic acid treated ground calcium carbonates commercially

available from English China Clay under the trademarks Supercoat® and Kotamite®.

The term "finely divided" when utilized herein means that the particulate materials have a median individual particle size below about 10 microns and preferably below about 3 microns and more preferably the median particle size is about one micron or less. Particle size and particle size distribution as used herein are measured with a Micromeritics Sedigraph 5100 Particle Size Analyzer. Measurements were recorded in deionized water for hydrophilic particles. Dispersions were prepared by weighing 4 grams of dry sample into a plastic beaker adding dispersant and diluting to the 80 ml mark with deionized water. The slurries were then stirred and set in an ultrasonic bath for 290 seconds. Typically, for kaolin 0.5% tetrasodium pyrophosphate is used as a dispersant; with calcium carbonate 1.0% Calgon T is used. Typical densities for the various powders are programmed into the sedigraph , e.g., 2.58 g/ml for kaolin. The sample cells are filled with the sample slurries and the X-rays are recorded and converted to particle size distribution curves by the Stokes equation. The median particle size is determined at the 50% level.

Preferably, the particulate material has a particle size distribution wherein up to 90% by weight of the particles have a particle size of under about 10 microns, preferably below about 3 microns and more preferably about one micron or less.

The particulate materials particularly suitable for use in this invention are inert and nontoxic.

As used herein "inert" particulate materials are particles that are not phytotoxic.

The particulate materials are preferably nontoxic meaning that in the limited quantities needed for effective enhanced horticultural effect such materials are not considered harmful to animals, the environment, the applicator and the ultimate consumer.

As previously discussed, this invention relates to horticultural crops wherein the surface of said crop is treated with one or more particulate materials. This treatment should not materially affect the exchange of gases on the surface of said crop. The gases which pass through the particle treatment are those which are typically exchanged through the surface skin of living plants. Such gases typically include water vapor, carbon dioxide, oxygen, nitrogen and volatile organics.

The surface of said horticultural crop is treated with an amount of one or more highly reflective particulate materials that is effective in enhancing photosynthesis of the horticultural crop. The treatment coverage of said crop is within the skill of the ordinary artesian. Less than full crop coverage is within the scope of this invention and can be highly effective, for example, neither the under surface of the crop (that which is not exposed directly to the source of light) need be treated by the method of this invention nor must the upper surface of the crop be completely covered; although full substrate coverage can

provide additional benefits such as effective disease control, smoother fruit surface, reduced bark and fruit cracking, and reduced russeting. Reference is made to U.S. Serial No. _____, filed concurrently herewith on _____, entitled "Treated Horticultural Substrates" which is incorporated herein by reference for its teachings regarding methods for achieving these additional benefits. The method of this invention may result in the residue of the treatment forming a membrane of one or more layers of highly reflective particulate materials on the crop surface.

The particulate materials useful for the purposes of this invention may be applied as a slurry of finely divided particles in a volatile liquid such as water, a low boiling organic solvent or low boiling organic solvent/water mixture. Adjuvants such as surfactants, dispersants or speaders/stickers (adhesives) may be incorporated in preparing an aqueous slurry of the particulate materials of this invention. One or more layers of this slurry can be sprayed or otherwise applied to the crop surface. The volatile liquid is preferably allowed to evaporate between coatings. The residue of this treatment may be hydrophilic or hydrophobic. Applying particles as a dust, although not being commercially practical on a large scale due to drift and inhalation hazards, is an alternative for carrying out the method of this invention.

Spreader/stickers that can be mixed with hydrophilic particles (3% or more solids in water) to aid in spraying uniform treatments on horticultural

substrates are: modified phthalic glycerlol alkyd resins such as Latron B-1956 from Rohm & Haas Co.; Plant oil based materials (cocodithalymide) with emulsifiers such as Sea-wet from Salsbury lab, Inc.; Polymeric terpenes such as Pinene II from Drexel Chem. Co.; nonionic detergents (ethoxylated tall oil fatty acids) such as Toximul 859 and Ninex MT-600 series from Stephan.

The the particle treatment may be applied as one or more layers of finely divided particulate material. The amount of material applied is within the skill of one of ordinary skill in the art. The amount will be sufficent to improve photosynthesis of the crop to which these particles are applied. Typically, this treatment will be most effective when crop surface is white in appearance. For example, this can typically be accomplished by applying from about 25 up to about 5000 micrograms of particulate material/cm^2 of crop surface for particles having specific density of around 2-3 g/cm^3, more typically from about 100 up to about 3000 and preferably from about 100 up to about 500. As the brightness of the highly reflective particles increases lesser amounts of these brighter particles are necessary to be effective for the purposes of this invention. In addition, environmental conditions such as wind and rain may reduce crop coverage of the highly reflective particulate materials and therefore it is within the scope of this invention to apply the highly reflective particles one or more times during the growing season of

said horticultural crop so as to maintain the desired effect of invention.

The low boiling organic liquids useful in the present invention are preferably water-miscible and contain from 1 to 6 carbon atoms. The term "low boiling" as used herein shall mean organic liquids which have a boiling point generally no more than 100°C. These liquids enable the particulate solids to remain in finely divided form without significant agglomeration. Such low boiling organic liquids are exemplified by: alcohols such as methanol, ethanol, propanol, i-propanol, i-butanol, and the like, ketones such as acetone, methyl ethyl ketone and the like, and cyclic ethers such as ethylene oxide, propylene oxide and tetrahydrofuran. Combinations of the above-mentioned liquids can also be employed. Methanol is the preferred low boiling organic liquid.

Low boiling organic liquids may be employed in applying the particles to crop substrates for the purposes of this invention. Typically, the liquids are used in an amount sufficient to form a dispersion of the particulate material. The amount of liquid is typically up to about 30 volume percent of the dispersion, preferably from about 3 up to about 5 volume percent, and most preferably from about 3.5 to about 4.5 volume percent. The particulate material is preferably added to a low boiling organic liquid to form a slurry and then this slurry is diluted with water to form an aqueous dispersion. The resulting slurry retains the particles in finely divided form wherein most of the

particles are dispersed to a particle size of less than about 10 microns.

The following examples are illustrative of embodiments of the invention and are not intended to limit the invention as encompassed by the claims forming part of the application.

EXAMPLE 1

"Red Delicious" apple trees received the following treatments: 1) Conventional pesticide applications applied according to the presence of economic levels of pests using the Virginia, West Virginia and Maryland Cooperative Extension 1997 Spray Bulletin for Commercial tree Fruit Growers publication 456-419, 2) no treatment, 3) weekly application of Translink® 77 beginning in March 11, 1997, 4) weekly application of calcined kaolin (Satintone® 5HP) beginning in April 29,1997, and 5) weekly application of treated calcium carbonate (SuperCoat® - commercially available from English China Clay) beginning in April 29, 1997. Treatments (3) and (5) applied 25 pounds material suspended in 4 gal methanol and added to 100 gal water. Treatment (4) applied 25 pounds material suspended in 100 gal water with the addition of 27oz Ninex® MT-603 and 2 pints Toximul. These treatments were applied at the rate of 125 gal/acre using an orchard sprayer. This mixture was applied at the rate of 125 gal/acre using an orchard sprayer. The treatments were arranged in a randomized complete block design with 4 replications and 3 trees/plot. Treatments were not irrigated and received

21.58 cm of precipitation from 1 May to 30 August 1997. Fruit were harvested at maturity; fruit number, weight and color were measured. Color was measured using a Hunter colorimeter. Color values represent Hunter "a" value units, in which increasing value represents increasing red color. Photosynthesis and stomatal conductance were measured on Aug 6 and 8, 1997. Photosynthesis and stomatal conductance data were collected using a Licor 6300 photosynthesis system. Increasing values of photosynthesis and stomatal conductance represent increasing assimilation of carbon dioxide from the atmosphere and transpiration of water from the leaf, respectively; both parameters reflect improved plant productivity when values increase. Treatments (1) and (3) were measured twice daily at 10 to 11 am and 2 to 3 pm. Three trees in each plot were measured with 2 sunlit leaves/tree. Canopy temperature was measured using an Everest Interscience (Model 110) infrared thermometer with +/- 0.5 °C accuracy, in which the temperature of the plant surface approximately 1 m in diameter was determined on the sunlit side of the tree. Data for canopy temperature are presented as the difference between leaf and air temperature. A negative canopy temperature denotes a canopy cooler than air temperature due to transpiration and heat reflection. The data are reported in Table I.

Table I

Treatment	Yield/tree (kg)	Fruit weight (g)	Red Color	Photosynthesis rate (μmoles $CO_2/m^2/sec$)	Stomatal conductance ($mol/m^2/sec$)	Canopy Temperature (C)
Conventional	43.7	136	19.7	6.7	0.35	-4.2
Control	30.1	123	23.2			
Translink®77	51.6	135	23.9	9.2	0.57	-5.2
Calcined Kaolin	37.6	124	21.0			
Treated CaC03	39.1	130	24.1			-5.5

The use of hydrophobic kaolin (Translink® 77) increased yield compared to conventional management (51.6 vs 43.7 kg, respectively) without a meaningful reduction in fruit size (135 vs 136 g/fruit).

The use of hydrophobic kaolin (Translink® 77) improved fruit color compared to the conventional management (23.9 vs 19.7). Treated $CaCO_3$ (SuperCoat®) and calcined Kaolin (Satintone® 5HB) also improved color compared to the conventional management (24.1 and 21.0 vs 19.7). The untreated control improved color compared to the conventional management (23.2 vs 19.7) but this is likely due to defoliation of the tree due to poor pest control since no pesticides were applied (see Lord and Greene, Ibid.). Defoliation from pest damage increases light to the fruit surface which increases color development. Pest control levels were adequate in all other treatments and did not result in defoliation.

Average precipitation approximates 35.6 cm from April 1 to August 30; precipitation was 40% below normal.

The application of Translink® 77 increased photosynthesis, stomatal conductance and reduced plant temperature. Stomatal conductance is a measure of the width of stomates on the underside of the leaf. Water loss, in the form of transpiration, occurs through the stomates and is controlled by the size of the stomatal opening. The greater the size of the opening, the greater is the stomatal conductance, and so transpiration is greater. Similarly, the greater the size of the stomatal opening, the greater is the influx of carbon dioxide necessary for photosynthesis. Canopy temperature was reduced by the application of Translink® 77 due to the increased transpirational cooling of the leaf related to increased stomatal conductance resulting from the application of Translink® 77. The application of calcium carbonate (SuperCoat®) also reduced plant temperature, presumably due to increased transpirational cooling of the leaf related to increased stomatal conductance.

<u>Yakima, WA</u>

"Red Delicious" apple trees received the following treatments: 1) no treatment; this untreated control did not have pest pressures that exceeded the threshold for pesticide application, 2) application of Translink® 77 on April 5, May 8, 29; June 25; July 14; September 4, 3) application of Translink® 77 on the same dates as "(2)"

and on May 22, June 9, and July 31. Treatments (2) and (3) applied 25 pounds material suspended in 4 gal methanol and added to 96 gal water. This mixture was applied at the rate of 100 gal/acre using an orchard sprayer. The treatments were arranged in a randomized complete block design with 3 replications of 3 trees/plot. Treatments were all irrigated on a weekly basis to meet plant water needs using sprinkler irrigation located beneath the trees. Photosynthesis and stomatal conductance were measured on July 17 to 20, 1997. Photosynthesis data were collected using a Licor 6300 photosynthesis system. Treatments (1) , (2) and (3) were measured twice daily at 10 to 11 am and 2 to 3 pm. Three trees in each plot were measured with 2 sunlight leaves/tree. Data are the mean values for all days and hours sampled. Canopy temperature was measured using an Everest Interscience Infrared (Model 110) thermometer with +/- 0.5 C accuracy, in which the temperature of the plant surface approximately 1 meter in diameter was determined on the sunlit side of the tree. Data for canopy temperature are presented as the difference between leaf and air temperature. A negative canopy temperature denotes a canopy cooler than air temperature due to transpiration and heat reflection. Canopy temperature data were collected from Aug 17 to 20, 1997. The data presented in Table IV are representative of the entire data set. At the time of harvest, 20 fruit were randomly collected from each of the 3 trees/plot (total of 180 fruit/treatment). Fruit were weighed and color determined. Color was determined

with a Hunter colorimeter. Color values represent Hunter "a" values.

Table II

Treatment	Fruit weight (g/fruit)	Photosyn-thesis (μmol $CO_2/m^2/sec$)	Stomatal conduct- ance ($mol/m^2/sec$)	Canopy temperature (°C)
Control	164	8.8	0.24	-4.5
Translink® 77 applied 7 times	177	11.8	0.43	-5.7
Translink® 77 applied 10 times	195	12.9	0.46	-6.0

Fruit size increased with increasing applications of Translink® 77.

Trees in the study had fruit size greater than the study in Kearneysville, WV due to the use of irrigation.

The reduced canopy temperature of both Translink® 77 treatments illustrates that the application of these particles can reduce plant temperature.

The application of Translink® 77 increased photosynthesis, stomatal conductance and reduced plant temperature. Canopy temperature was reduced by the application of Translink® 77 due to the increased transpirational cooling of the leaf related to increased stomatal conductance resulting from the application of Translink® 77. Reducing the frequency of application from 7 applications did reduce photosynthesis, stomatal conductance, and canopy temperature compared to 10 applications, demonstrating that there is a beneficial

response to increasing amounts of Translink® 77 coverage.

Example 3

Santiago, Chile

"September Lady" peach, spaced 4m x 6m, received the following treatments: 1) Conventional pesticide application applied according to the presence of economic levels of pests, 2) no treatment, 3) weekly application of Translink® 77 beginning October 29, 1996. Treatment (3) applied 25 pounds material suspended in 4 gal methanol and added to 96 gal water. This mixture was applied at the rate of 100 gal/acre using a high pressure hand sprayer. Treatments were irrigated weekly using surface irrigation. Fruit were harvested at maturity and the number and weight measured. The data are reported in Table III.

Table III

Treatment	Yield/tree (kg)	Fruit weight (g)	Fruit number/tree
Conventional	13.9	156	94
Control	14.6	139	109
Translink® 77	25.4	137	156

The use of hydrophobic kaolin (Translink® 77) increased yield compared to the conventional treatment and the control by increasing the number of fruit/tree. Fruit size was reduced, although not statistically, from 156 to 137 g due to the larger number of fruit on the peach tree (94 vs 156).

Example 4

Biglerville, Pa--Dan Pack Orchard

"Golden Delicious" apples received 3 treatments: 1) commercial pesticide application applied according to the presence of economic levels of pests using the Virginia, West Virginia and Maryland Cooperative Extension 1997 Spray Bulletin for Commercial tree Fruit Growers publication 456-419, 2) full rate of Translink® 77, and 3) half rate of Translink® 77. Treatments (2) and (3) applied 25 and 12.5 pounds material, respectively, suspended in 4 and 2 gal methanol, respectively, and added to 100 gal water. This mixture was applied at the rate of 200 gal/acre using an orchard sprayer. The treated area was approximately 1 acre plots with 2 replications of each treatment in a randomized block design. At harvest the plots were commercially harvested and processed by a commercial grading line. At the time of grading, 100 fruit from each plot were randomly chosen to determine fruit size, color, and surface defects. Color was determined using a Hunter colorimeter. Green color values represent Hunter "a" values in which higher values represent more yellow color, a beneficial trait in "Golden Delicious" apple. The data are reported in Table IV.

Table IV

Treatment	Fruit size (mm)	Green color
Translink® 77 full rate	69	-8.0
Translink® 77 half rate	67	-8.9
Conventional	67	-10.0

Application of Translink® 77 at the full and half rate reduced green color, and Translink® 77 at the full rate increased fruit size compared to the half rate and conventional treatment.

"Stayman" apples received 2 treatments: 1) commercial pesticide application applied according to the presence of economic levels of pests using the Virginia, West Virginia and Maryland Cooperative Extension 1997 Spray Bulletin for Commercial tree Fruit Growers publication 456-419, 2) Translink® 77 treatment applied 25 pounds material suspended in 4 gal methanol and added to 96 gal water. This mixture was applied at the rate of 200 gal/acre using an orchard sprayer. Each treatment was applied to 1 acre blocks with no randomization. Apples were harvested commercially and processed on a commercial grading line. Data presented represent percent packout from the commercial grading line. The data are reported in Table V.

Table V

Treatment	Fruit size (mm)	<2.5 inches (%)	2.5 - 2.75 inches (%)	2.75 - 3.0 inches (%)	> 3.0 inches (%)
Translink® 77	69	11	38	44	7
Conventional	62	66	28	6	0

The application of Translink® 77 increased the packout of larger fruit and reduced the losses due to small fruit (<2.5 inches) compared to the conventional treatment.

WHAT IS CLAIMED IS:

1. A method for enhancing the photosynthesis of horticultural crops which comprises applying to the surface of said horticultural crop an effective amount of one or more highly reflective particulate materials, said particulate materials being finely divided, and wherein the particles as applied allow for the exchange of gases on the surface of said crop.

2. The method according to claim 1 wherein said particles have a Block Brightness of at least about 90.

3. The method of claim 1 wherein said particulate materials are hydrophobic.

4. The method of claim 1 wherein said particulate materials are hydrophilic.

5. The method of claim 1 wherein the particulate material has a particle size distribution wherein up to 90% of the particles have a particle size of under about 10 microns.

6. The method of claim 1 wherein the particulate material comprises a hydrophilic core and a hydrophobic outer surface.

7. The method of claim 6 wherein said hydrophilic core materials are selected from the group consisting of calcium carbonate, mica, kaolin, bentonite, clays,

pyrophyllite, silica, feldspar, sand, quartz, chalk, limestone, diatomaceous earth, baryte, aluminum trihydrate, titanium dioxide and mixtures thereof

8. The method of claim 4 wherein said hydrophilic materials are selected from the group consisting of calcium carbonate, talc, hydrous kaolin, calcined kaolin,, bentonites, clays, pyrophyllite, silica, feldspar, sand, quartz, chalk, limestone, precipitated calcium carbonate, diatomaceous earth, barytes, aluminum trihydrate, pyrogenic silica, titanium dioxide and mixtures thereof.

9. The method of claim 6 wherein said hydrophobic outer surface materials are selected from the group consisting of organic titanates, organic zirconate or aluminate coupling agents, organofunctional silanes, modified silicone fluids and fatty acids and salts thereof.

10. The method of claim 1 wherein the horticultural crop is selected from actively growing or fruiting agricultural and ornamental crops.

11. The method of claim 1 wherein the horticultural crop is selected from the group consisting of fruits, vegetables, trees, flowers, grasses, roots, seeds and landscape and ornamental plants.

12. The method of claim 1 wherein the finely divided particulate materials have a median individual particle size below about 3 microns.

13. The method of claim 6 wherein the hydrophilic core particulate materials are selected from the group consisting of calcium carbonate, calcined kaolin and mixtures thereof.

14. The method of claim 4 wherein the hydrophilic particulate materials are selected from the group consisting of calcium carbonate, calcined kaolin and mixtures thereof.

15. A method for enhancing the photosynthesis of horticultural crops which comprises applying to the surface of a actively growing or fruiting horticultural crop selected from the group consisting of fruits, vegetables, trees, flowers, grasses, roots, seeds and landscape and ornamental plants which comprises applying to the surface of said horticultural crop an effective amount of a slurry of one or more highly reflective particulate materials having a Block Brightness of at least about 90, said materials comprising one or more particulate materials, selected from the group consisting of calcium carbonate, calcined kaolin and mixtures thereof, said particulate materials have a median individual particle size of about one micron or less, and wherein said particles as applied allow for the exchange of gases on the surface of said crop.

16. The method of claim 1 or 15 wherein the finely divided particulate materials are applied one or more times during the growing season of said horticultural crop.

ABSTRACT OF THE DISCLOSURE

Disclosed is a method for enhancing the photosynthesis of horticultural crops which involves treating the surface of said horticultural crop with an effective amount of one or more highly reflective particulate materials.

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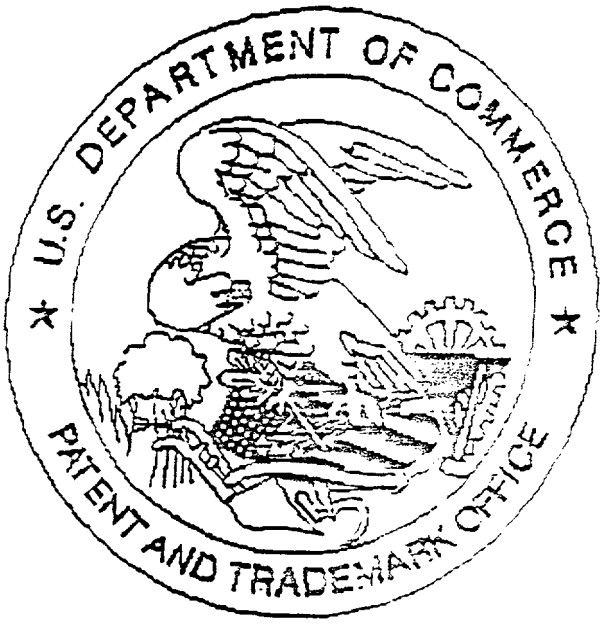

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